Patent Application of

Thomas Kagi, Sr.

For

Title: Waste Oil Multi-Fuel Fired Burner

CROSS REFERENCE TO RELATED APPLICATIONS: Not applicable.

FEDERALLY SPONSORED RESEARCH: Not applicable.

SEQUENCE LISTING OR PROGRAM: Not applicable.

BACKGROUND OF THE INVENTION – FIELD OF THE INVENTION

The subject invention relates to burners used for the combustion of liquid fuels, specifically to an improved burner design for accommodating the unique properties of high-viscosity and waste oil.

In the United States alone, an estimated 3 billion gallons of waste oil are generated annually. Disposal of this potentially hazardous substance is possible in a number of different ways. Perhaps the most environmentally sound and economically efficient method is by combustion for commercial or domestic heating purposes.

Much of the waste oil produced in the United States is attributable to small establishments (i.e., small automotive repair shops and garages, businesses specializing in automotive oil changes, etc.). Burning waste oil to provide space heat or hot water for such operations would be preferable to paying the high costs of proper disposal or transportation for reprocessing. Unfortunately, the cost of waste oil burners in terms of initial capital outlay, installation, operation, and maintenance is often prohibitive. In addition, serious questions remain as to the safety and reliability of some waste oil

burners on the market today.

Due to the unique and variable properties of waste oil supplies, conventional furnace oil burners, with their standard safety features, are not effective in the combustion of waste oil. Waste oil possesses characteristics far different from conventional furnace fuels; waste oil is typically very high in viscosity and replete with incombustible contaminants making combustion difficult by usual means. In addition, waste oil supplies frequently vary in viscosity and contaminant level and on occasion a waste oil furnace owner may choose to burn furnace fuel rather than waste oil in a waste oil burner. Therefore, it is important that a waste oil burner be easily and effectively adjustable to accommodate fuels of varying composition and viscosity.

The present invention proposes a unique and simple burner design that, when used in conjunction with an emissions scrubber such as that disclosed by U.S. Pat. No. 5,041,274, Aug. 20, 1991, Kagi, will provide a safe, efficient, cost-effective, and environmentally sound method of waste oil disposal.

DISCUSSION OF PRIOR ART AND OVERVIEW OF CONVENTIONAL WASTE OIL BURNER STRUCTURE AND MANNER OF OPERATION.

Most waste oil burners operate in a similar manner: waste oil is filtered of contaminants and preheated in order to reduce oil viscosity. Next, a gear-driven oil pump transports oil to the burner from a remote source. On reaching the burner, the oil is suctioned through a low-pressure, aspiration-type nozzle by a compressed air current in order to break up the oil flow into a fine mist as required for proper combustion. The process of breaking up the oil flow into microscopic droplets is called "atomization." The atomized oil is then ignited by a set of electrodes. In many waste oil burners, a constant

spark is required to initiate combustion. In addition, prior art waste oil burners typically require oil solenoid valves to stop the flow of pressurized fuel through the nozzle after the burner is shut down. Upon cessation of operation, oil solenoid valves tend to leak or drip oil into the fire chamber which will cause smoking, and creation of foul fumes upon subsequent start up.

In the prior art, once flame is established, the combustion rate must be monitored to avoid "over-firing" or "under-firing" the furnace. Over-firing occurs when the flame length approaches the back wall, or "target", of the combustion chamber. Flame length increases with combustion rate in most waste oil furnaces because the secondary air required for combustion is fed parallel to the oil flow. If the combustion chamber is allowed to overheat, an explosion of the unit is possible; therefore, most waste oil burners have a fairly limited firing capacity and are engineered to shut down in the event of over-firing. Under-firing is a less serious condition, usually caused by an excessively viscous fuel supply and is characterized by a weak, erratic flame and low heat output.

While numerous patents have been issued for waste oil burners of acceptable operation, all waste oil burners heretofore known suffer from a number of disadvantages in addition to those mentioned above:

Oil Preheating Required. As described above, waste oil must be atomized into microscopic droplets in order to create greater surface area and achieve a complete burn. Waste oil is very high in viscosity; therefore, waste oil burners must preheat the oil in order to lower the viscosity and obtain maximum atomization. Unfortunately, heating waste oil to high temperatures also causes oil carbonization or "sludging" of the oil which can clog nozzles, thereby reducing burner efficiency or rendering the burner inoperable.

The cost of high-temperature preheating also detracts from the economic savings sought by most waste oil furnace owners.

Lack of Oil Flow Rate Control. Waste oil supplies frequently vary in viscosity and contaminant level and on occasion a waste oil furnace owner may choose to burn furnace fuel rather than waste oil in a waste oil burner. Therefore, it is important that a waste oil burner be easily adjustable to accommodate fuels of varying composition and viscosity to avoid burner over or under-firing. Many current waste oil burners do not feature an effective method of oil flow regulation making said burners susceptible to under-firing or over-firing. An under-firing condition, characterized by a weak, irregular flame and low heat output, may result if the oil flow rate cannot be adjusted to accommodate the common problem of extremely high viscosity oil.

If the oil flow rate of a burner cannot be adjusted for low viscosity fuel, inadvertent over-firing is also possible. When oil pressure remains constant, low-viscosity oil is capable of flowing at an increased rate through a nozzle for ignition. As explained previously, an elevated oil flow rate may lead to a dangerously elongated flame, frequently an indicator of over-firing in burners that feed secondary combustion air parallel to the oil flow.

Many waste oil burners on the market today can be inadvertently over-fired, creating an extremely hazardous situation, because such burners do not possess a means of oil flow regulation. Furnace manufacturers that use a constant volume flow pump can create a hazardous situation if the pump inadvertently exudes too much oil. As a safety precaution, such waste oil furnaces usually contain an automatic temperature limit switch to shut down the burner in the event of overheating. A consequence of these

necessary safety precautions is an inherent limit on BTU output.

Combustion Rate Necessarily Limited to Avoid Over-Firing. Conventional waste oil burners address the risk of over-firing and its associated hazards by limiting heat output. Waste oil burner manufacturers generally install a temperature-sensitive switch that will automatically shut down the burner in the event of over-heating. BTU output is necessarily limited in such designs since an increase in combustion rate varies directly with flame length and heat output.

Therefore, in order to provide a wide variety of BTU output levels, waste oil furnace manufacturers must generally produce several different-sized furnace models; one standard size furnace of a typical design, that lacks an effective method of fuel flow rate control is not capable of providing a widely variable heat output.

Oil Solenoid Valves Required. Conventional waste oil burners require the use of an oil solenoid valve to stop the flow of pressurized oil through the nozzle after the burner ceases operation. The leakage of oil into a "cold" combustion chamber can result in difficult ignition, a foul smell and profuse smoke upon later burner operation, and the creation of deposits in the burner chamber leading to irregularities in burner performance.

EVALUATION OF PRIOR PATENTS

Several embodiments have been identified and distinguished in the prior art:

1. U.S. Pat. No. 5,149,260, Sep. 22, 1992, Foust and U.S. Pat. No. 5,341, 832, August 30, 1994, Foust, both present a closed-loop oil circulation and preheating apparatus involving an oil pump, oil preheating mode, self-cleaning "atomizing gun", and a control system. The atomizing gun allows preheated oil to be redirected from the circulatory loop to a low-pressure, aspiration-type nozzle where it is combined with compressed air and

atomized for combustion. This system is most likely incapable of generating oil pressure at the nozzle in excess of 40 BTU. The circulating oil is maintained at a constant preheated temperature, thereby promoting oxidization, "sludging," and unreliable start-up and operation from carbon particles plugging the discharge nozzle. For this reason a long needle for periodically cleaning the nozzle is installed in the Foust burner similar to a camp fire stove where the nozzle has a built in needle cleaner to open the nozzle orifice whenever it plugs up.

2. U.S. Pat. No. 4,487,571, Dec. 11, 1984, Robertson, et. al., utilizes a remote conventional oil pump to deliver fuel oil to an intermediate reservoir wherein a portion of the oil flow is sent through a restricted return line back to the fuel source. The restricted return line creates sufficient oil pressure to redirect a predetermined portion of the oil flow from the intermediate reservoir to a preheated aspiration-type nozzle for atomization and combustion. The system relies on a conventional oil pump, compressed air supply for atomization, and oil preheating. An oil solenoid valve would be necessary to stop post-operation oil leakage due to residual oil pressure at the nozzle. This system lacks a method of oil flow rate control and is particularly inappropriate for burning extremely high viscosity oil due to the nature of the fuel delivery system employed; the oil pressure induced by the restricted return line may not be sufficient to redirect extremely high viscosity oil to the nozzle at an adequate and constant rate. The potentially sluggish, irregular oil flow to the nozzle under such circumstances would result in a weak, erratic flame.

3. The burner apparatus embodied by U.S. Pat. No. 4,416,609, Nov. 22, 1983, Weber, discloses a complex fuel delivery system involving a closed-loop oil circulation

system and a series of tanks or vessels. The vacuum effect of gas under pressure and overpressure is used to transport oil between the vessels and eventually out an atomizing nozzle for combustion. No conventional oil pumps are used; however, an air pump and compressed air supply are required to create the desired pressurization and vacuum effects. This system appears to lack a method of oil flow rate control and would probably require an oil solenoid-type valve to stop pressurized oil leakage from the nozzle after the burner ceases operation.

It should be noted that regulatory agencies group waste oil with gasoline as a "Class 1" highly-flammable substance. Most U.S. jurisdictions therefore limit or entirely prohibit the pressurization of Class 1 fuel storage vessels due to the associated risks of fire or explosion.

4. U.S. Pat. No. 3,914,094, Oct. 21, 1975, Landry, presents a waste oil burner intended for use on an oil well drilling barge and is designed to address the problems created by fluctuations in oil pressurization. The Landry burner is intended for use outdoors without a combustion chamber to enclose the burner and flame and utilizes natural gas for ignition. A remote oil pump is employed to pressurize the oil for transportation to the burner. A dill valve and bellows member act as a check valve on the oil flow to the nozzle and thereby ameliorate the effects of oil pressure fluctuations. The bellows member does not generate oil pressure but permits fuel pressurized by the remote oil pump to accumulate therein to a predetermined level (500 psig maximum) before the oil is released. After release from the bellows member, the fuel supply is siphoned by a compressed air flow through a nozzle and thereby atomized for combustion.

5. U.S. Pat. No. 3,720,496, Mar. 13, 1973, Briggs emphasizes a unique flame retention cone on a burner of typical design which mixes compressed air and fuel oil in a discharge nozzle for atomization and combustion. An oil solenoid valve would likely be required to stop the flow of oil through the nozzle post-operation. This invention appears to lack a method of oil flow rate control and the oil pressure level is probably between 20 and 30 PSI at the nozzle. The Briggs retention head is conical in shape with a pattern of a few small openings causing air flow resistance and low light transfer for the flame detector. The flame cone structure required to "spin" the air for added combustion air as required to promote an efficient burn is inadequate in design. As compared to the Kagi retention head.

6. U.S. Pat. No. 331,104, November 17, 1992, Bender presents a burner assembly that combines a burner, nozzle holder, heat exchange block and control valve that fits inside an elongated blast tube that can be removed from the rear for easy service and maintenance. Placement of the preheater unit inside the blast tube restricts combustion air flow thereby limiting maximum BTU output especially for high output furnaces and boilers. The chemical law of combining states so much fuel will require a given amount of oxygen.. The small diameter of the preheater inherently restricts the size of the preheating elements which will necessitate using small diameter heating elements that will have short longevity and insufficient BTU output for high BTU requirements. A pre-spin blade attached to the holding bracket lacks a good secondary air spin pre-se is limited to a double blade attached to the guiding support that holds the burner unit.

7. U.S. Pat. No. 5,080,579, January 14, 1992, Specht, presents a two-stage apparatus for preheating waste oil, utilizing primary and secondary preheater units. The primary preheating unit is located furthest from the burner unit and preheats only when the burner is in operation; the secondary preheater is wrapped around the nozzle holder and is maintained in a constant heat mode. The Specht preheater design presents several problems that are avoided by the subject design, primarily, the nozzle assembly is maintained at a constant atomization temperature which would cause the oil to oxidize (carbonize) and clog the nozzle.

8. U.S. Pat. No. 4,877,395 October 31, 1989, Schubach, and U.S. Pat No. 4,797,089 January 10, 1989 Schubach present similar system controls for preheating waste oil. Both of these prior art embodiments are deficient in that the pre-heated oil is maintained at a constant high temperature; only one heating element is provided thereby limiting the capacity to heat a high flow of oil for combustion; there is no separate means presented for preheating the air for combustion and no method presented for avoiding or unclogging plugged nozzles, the inevitable result of maintaining the fuel supply at a constantly hot temperature.

None of the above described prior art possess a cumulative air tank, or unique design of the present two-stage preheater assembly; none are designed to preheat, atomize and combust the fuel supply in the same manner as the present method and apparatus. The prior disclosed art are generally more complex, expensive and difficult to manufacture, install, operate and maintain, are necessarily more cumbersome and larger in size, have more elements susceptible to malfunction, and are not able to accommodate extreme fluctuations in fuel viscosity. In addition, the prior art may be less safe and

reliable than the burner here presented.

OBJECTS AND ADVANTAGES:

Several objects and advantages of the present embodiment are identified:

Oil Flow Rate is Adjustable. The rate at which fuel is supplied for combustion in the Kagi Burner can be quickly and easily adjusted. The Kagi Burner is therefore suitable for the combustion of a wide range of fuel compositions and viscosities and is less susceptible to over-firing caused by the introduction of low-viscosity fuel or to the weak, irregular flame attributable to the combustion of extremely high-viscosity oil.

In addition, the present invention's method of oil flow regulation provides a burner with an adjustable BTU output capable of meeting a wide range of individual heating needs.

Constant Spark Igniters Not Required. Many waste oil burners require constant spark igniters to keep the burner in a continuously firing mode. Constant spark igniters have a relatively short useful life expectancy and add to the cost of operating and maintaining a waste oil burner. The present invention does not require constant spark igniters to initiate and maintain combustion.

Unique Retention Head. While a ceramic chamber liner, standard retention head, or other flame barrier may be employed to promote complete combustion and protect the combustion chamber by controlling flame spread and dissipating heat in prior art versions, the preferred embodiment contemplates an improved retention head of unique design and unparalleled function.

The contemplated flame retention head is substantially cylindrical in shape, with a number of rectangular blades or fins around the circumference of one end which

are angled toward the centerline of the cylindrical retention head. A small space exists between each of the retention head blades or fins, thereby allowing light from the combustion flame to be detected and not obscured by a cad cell or other flame sensor. The retention head fins or blades are angled to obtain maximum efficiency at spinning the combustion air. The subject flame retention head also has a sleeve on the circumference of its outer edge furthest from the source of the flame to divert oil spray back into the burn zone of the flame thereby promoting complete combustion.

The retention head fins or blades and openings in-between are designed to create a secondary air flow around the interior surface of the retention head which envelopes the atomized oil flow and flame in a circular, spinning fashion. The aerodynamic effect produced by the retention head blade, fine and opening features forces the oil mist and flame toward the centerline of the retention head, while containing the oil supply and flame close to the nozzle in a spherical pattern and away from the combustion chamber target wall.

Any oil droplets larger in size than required for complete, clean combustion are forced back into the combustion zone by the spinning air flow, rather than being allowed to deviate by centrifugal force and collect in the combustion chamber.

The retention head depicted in the preferred embodiment also allows secondary air to encounter the flame in a circular, spinning fashion thereby forcing the flame to increase in girth, rather than elongate, producing a flame with a spherical shape when the oil combustion rate is elevated. The retention head described thereby serves as an inherent guard against inadvertent over-firing by reducing the likelihood that the flame will reach the combustion chamber target wall.

Because a higher combustion rate can be achieved with a reduced risk of excessive flame elongation and over-firing, the Kagi Burner permits greater BTU output from a smaller-sized burner than heretofore possible.

Accordingly, aside from the objects and advantages of the waste oil burner described above, several objects and advantages of the present invention are:

(a) to provide a waste oil burner of safe, effective, efficient, and reliable operation;

(b) to provide a durable, low-maintenance waste oil burner;

(c) to provide a waste oil burner with an adjustable oil flow rate capable of accommodating a wide range of fuel compositions and viscosities;

(d) to provide a waste oil burner that does not leak fuel into the combustion chamber after the burner ceases operation;

(e) to provide a waste oil burner that does not require constant, high-temperature fuel pre-heating;

(f) to provide a waste oil burner with a retention head that protects the combustion chamber by dissipating heat and controlling flame spread, limits flame elongation, and promotes efficiency through more complete combustion;

(g) to provide a waste oil burner that is simple to use and easy to adjust and maintain;

(h) to provide a waste oil burner of relatively compact size and high BTU output;

(i) to provide a waste oil burner that utilizes a novel method of effectively precluding oil discharge from the nozzle when the burner ceases operation;

(j) to provide a waste oil burner that will ignite at elevated air pressure settings as may be required for atomization and burning of large volumes of viscous oil; and

(k) to provide a waste oil burner that is easily expandable by increasing the number of nozzle and preheater assemblies as required to exponentially increase combustion volume and BTU output capability.

SUMMARY

The simple design of the subject fuel burner thereby allows for less expensive manufacture, shipping, installation, operation, and maintenance than for burners previously contemplated.

The Kagi Burner also provides an efficient means for oil flow regulation, permitting safer, more reliable operation than the prior art. The present invention provides an adjustable heat output furnace with a higher maximum BTU output level in a smaller size than ever before possible.

The preferred embodiment features a flame retention head that dissipates heat, controls flame spread, ensures a complete burn, and allows for operation at a higher combustion rate (for greater BTU output) with a substantially reduced risk of furnace over-firing.

Further objects and advantages of this invention will become apparent from a consideration of the drawings and ensuing description.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows a TOP view of the preferred embodiment.

FIG. 2 shows a TOP cross-sectional view of the preferred preheater block embodiment.

FIG. 3 shows a RIGHT cross-sectional view of the preferred embodiment.

FIG. 4 shows a LEFT cross-sectional view of the preferred embodiment.

FIG. 5 shows a REAR view of the preferred embodiment.

FIG. 6 shows a FRONT view of the preferred embodiment.

FIG. 7 shows a SIDE cross sectional view of the preferred embodiment flame retention head.

LIST OF DRAWING REFERENCE NUMERALS

1. Preheater Block
2. Oil Entry Port
3. Oil Regulator
4. Oil Pressure Gauges
5. Oil Solenoid
6. Oil Preheater Chamber
7. Oil Preheater Element
8. Oil Passages
9. Nozzle
10. Air Pressure Regulators
11. Air Solenoid
12. Air Pressure Gauges
13. Cumulative Air Pressure Tank

14. Air Tank Support Bracket
15. Air Preheater Chamber
16. Air Pressure Delivery Tube
17. Air Preheater Element
18. Heat Conducting Rods
19. Air Passages
20. Air Pressure Switch
21. Preheater Block Thermostat
22. Oil Delivery Tube
23. Ignition Device
24. Blast Tube
25. Flame Retention Head
26. Flame Retention Head Fins Or Blades
27. Flame Retention Head Sleeve
28. Cad Cell Or Flame Sensor
29. Primary Control
30. Squirrel Cage Fan Blower
31. Individual Nozzle Power Switches

NARRATIVE DESCRIPTION

When the Kagi Multi-Fueled Burner calls for heat, cold waste oil or other liquid fuel, transported from a remote pump enters a **preheater block Fig 1 (1)** through an **oil entrance port Fig. 5 (2)**. The fuel passes through an **oil regulator Fig. 1 (3)** and **oil gauge Fig. 1 (4)**, through an **oil solenoid valve Fig. 1 (5),** into an **oil chamber Fig 2 (6)** and flows over an **oil preheating element Fig. 2 (7)**. The oil then zigzags through a series of **oil passages Fig. 2 (8)**, inside the **preheater block Fig. 1 (1)**, absorbing latent heat on its way to the **nozzle Fig. 2 (9)**. Pressurized air from a remote source enters the burner assembly through an **air regulator Fig. 1 (10)** which reduces the line air pressure from approximately 200 PSI to approximately 15-20 PSI before the compressed air enters an **air solenoid valve Fig. 1 (11)**, a valve that is normally closed.

When the **air solenoid valve Fig. 1 (11)** is energized by a call for heat, compressed air exits the **air solenoid valve Fig. 1 (11)** and an **air pressure gauge Fig. 1 (12)** in communication with an **air regulator Fig. 1 (10)** monitors air pressure entering the **air regulator Fig. 1 (10)**.

The pressurized air then proceeds into a **cumulative air storage tank Fig. 1 (13),** affixed to the burner housing by a **bracket Fig. 1 (14)**. Compressed air gradually exits the **cumulative air storage air tank Fig.1 (13)** into an **air preheating chamber Fig. 2 (15)** located inside the **preheater block Fig. 1 (1)** through an **air delivery tube Fig. 1 (16).**

The **air preheating chamber Fig. 2 (15)** within **the preheater block Fig. 1 (1)** possesses a separate **air heating element Fig. 2 (17)** that constantly preheats the

pressurized air. The **air preheating chamber Fig. 2 (15)** possesses a series of **heat conduction rods Fig. 2 (18)** that dissipate excess heat from the **air preheater element Fig. 2 (17)** to the external surface of the **preheater block Fig. 1 (1).**

The preheated air zigzags through **air passages Fig. 2 (19)** within the **preheater block Fig. 1 (1),** where the air absorbs latent heat. The air flows over the hot surface of the **air preheating element Fig. 2 (17)** and on toward the **nozzle Fig. 2 (9)**.

Pressurized air in the **air passages Fig. 1 (19)** of the **preheater block Fig. 1 (1)** is in pressurized communication with an **air pressure switch Fig. 1 and Fig. 2 (20)** that activates current to the remote fuel supply pump at a preset level of air pressure.

The **air preheating element Fig. 2 (17)** is set to a preset temperature established by a **block thermostat Fig. 2 (21)**. The **block thermostat Fig. 2 (21)** is maintained in an "on" position at all times.

Upon a call for heat, the compressed, preheated air rushes out of the **nozzle Fig. 1 (9)**, with a vacuum effect that suctions oil from the adjacent **oil delivery tube Fig. 1 (22)** at the **nozzle Fig. 1 (9),** spinning and atomizing the oil as it passes through the **nozzle Fig. 1 (9),** thereby enriching the fuel-to-air mixture into a fine spray or mist and promoting reliable ignition.

The atomized oil mixed with compressed air exists the **nozzle Fig. 1 (9)** in proximity to one or more ignition devices or **electrodes Fig. 1 (23),** causing immediate ignition of the atomized fuel mixture.

Once ignited, the flame extends from the **nozzle Fig. 1 (9)**, through a **blast tube Fig. 1 (24)** and unique **flame retention head Fig. 1 (25)** possessing a **plurality of fins or blades Fig. 1 (26)** and a **sleeve Fig. 1 (27)** on the remote end. Inside the **flame retention head Fig 1 (22)**, the flame is detected by a cad cell or other **flame sensor Fig. 1 (28).**

When the cad cell or **flame sensor Fig. 1 (28)** detects the presence of flame, the **primary control Fig. 5 & Fig. 6 (29)** will allow the burner to continue to function. When the **flame sensor Fig. 1 (28)** fails to detect the presence of flame from the **nozzle Fig. 1 (9)** (i.e., "flame out"), the primary control **Fig. 5 & Fig 6 (29)** automatically and immediately shuts down the burner.

A **squirrel cage blower Fig.1 (30)** is attached to the burner housing and forces air into the **blast tube Fig. 1 (24)** and **flame retention head Fig. 1 (25)**, thereby releasing heated air into the surrounding environment.

ADDITIONAL EMBODIMENTS:

The preferred embodiment can be expanded to include multiple nozzles and additional associated components as required to service the additional nozzles in order to exponentially increase BTU output. When multiple nozzles are utilized, additional air supply is required to each nozzle. Independent energizing toggle or other **power activation switches Fig. 1 (31)** can be utilized to independently control each additional nozzle and each additional pressurized air supply. **Independent oil solenoids Fig. 1(5), oil regulators Fig. 1 (3)** and **gauges Fig. 1 (4)** and **independent air solenoids Fig. (11), air regulators Fig. 1 (10)**, and **air gauges Fig. (12)** are required for each additional

nozzle assembly. In an expanded embodiment, additional **preheater blocks Fig. 1 (1)**, including all internal components may also be required.

EXPLANATION OF OPERATION

When a remote wall thermostat or aquastat (for boiler use) is in a "closed" status, thereby calling for heat from the burner, the burner becomes energized, and all electrical components, such as the combustion **blower motor Fig. 1 (30), oil** and **air solenoids Fig. 1 (5)** and **(11)** respectively, and the transformer or other source of power for the flame **igniters Fig. 1 (23)** become activated.

Compressed air from an outside source enters the **air regulator Fig. 1(10)**, and then passes to an **air solenoid Fig.1 (11)**, which is normally closed when the burner is cycled off. The **air solenoid Fig. 1 (11)** is opened when the burner calls for heat, allowing the compressed air to enter a **cumulative air tank Fig. 1 (13)**. An **air pressure gauge Fig. 1 (12)** monitors air pressure exiting the **cumulative air tank Fig. 1 (13)** and allows adjustment of air pressure to accommodate the amount of oil being burnt before the air reaches the discharge **nozzle Fig.1 (9)**.

As the **cumulative air tank Fig. 1 (13)** is filled, air gradually exits the **cumulative air tank Fig. 1 (13)** and flows toward the **nozzle Fig.1 (9)**, thereby enriching the fuel to air mixture and facilitating ignition.

When the **air solenoid or valve Fig 1 (11)** is activated, pressurized air from an external source feeds to an **air pressure switch Fig. 1 (20)**, which in turn supplies current to an external fuel pump. The remote fuel pump pushes fuel to an **oil regulator Fig. 1 (3)**, which can be used to adjust the flow of oil to the burner and thereby regulate the oil burning rate.

The oil from the **oil regulator Fig. 1 (3)** enters an **oil solenoid Fig 1. (5),** that is normally closed. When the burner is activated, the **oil solenoid Fig 1. (5),** opens allowing oil to flow directly to the atomizing discharge **nozzle Fig. 1 (9)** through an **oil delivery tube Fig. 1 (22),** in communication with pressurized, preheated air flowing out the **nozzle Fig. 1 (9).** The pressurized, preheated air flowing through the discharge **nozzle Fig. 1 (9)** adjacent to the flow of oil from the **oil delivery tube Fig. 1 (22)** has the effect of suctioning and mixing the preheated, pressurized oil through the **nozzle Fig. 1 (9),** thus, promoting atomization of the oil as it is expelled through the **nozzle Fig. 1 (9).**

A transformer or other power supply (not shown) is also activated upon a call for heat and arcs across a set of electrodes or other flame **ignition device Fig. 1 (23),** which directs spark toward the mist of atomized oil exiting the **nozzle Fig. 1 (9).**

In the preferred embodiment, the **nozzle Fig. 1 (9)** and **electrodes or igniters Fig. (23)** are enveloped by a unique **flame retention head Fig. 1 (25)** which serves the multiple purposes of chamber protection through heat dissipation and re-direction from the chamber target, and flame spread control that promotes complete combustion.

The **retention head Fig. 1 (25)** contemplated is substantially cylindrical in shape, the remote end of which possesses a **plurality of fins or blades Fig. 1 (26) that are** angled toward the centerline of the **retention head Fig. 1 (25)** with an air gap between each **blade or fin Fig. 1 (26)** to avoid obstructing light emitted from the combustion flame from being detected by the cad cell or **flame sensor Fig. 1 (28).**

The **blades or fins Fig. 1 (26)** of the subject **flame retention head Fig. 1 (25)** are angled in a direction opposite of the rotation of the atomized oil spray emitted from the **nozzle Fig. 1 (9)** in order to achieve maximum atomization.

A **sleeve Fig. 1 (27)** is installed on the circumference of the furthest end of the **retention head Fig. 1 (25)** to direct oil spray and secondary air flow toward the center of the **retention head Fig. 1 (25),** sending the atomized oil and resulting flame into a circular, spinning configuration. The aerodynamic effect produced by the combination of **fins, blades and openings Fig. 1 (26)** inside the **retention head Fig. 1 (25)** forces the atomized fuel and flame toward the centerline of the retention head, while containing the fuel supply and flame close to the **nozzle Fig. 1 (9)** and away from the combustion chamber target wall.

Any oil droplets larger in size than required for complete, clean combustion are forced into the combustion zone by the spinning air flow, rather than being allowed to deviate and collect on the retention head and fire chamber interior.

The **retention head Fig. 1 (25)** depicted in the preferred embodiment also allows secondary air to encounter the flame in a circular, spinning fashion thereby forcing the flame to increase in girth, rather than elongate, when the oil combustion rate is elevated. The **retention head Fig. 1 (25)** described thereby serves as an inherent guard against inadvertent over-firing by reducing the likelihood that the flame will reach the combustion chamber target wall.

Because a higher combustion rate can be achieved with a reduced risk of excessive flame elongation and over-firing, the Kagi Burner permits greater BTU output from a smaller-sized burner than heretofore possible.

OBJECTS AND ADVANTAGES OF THE INVENTION

The subject invention presents an improved method and apparatus for the delivery, atomization, and combustion of liquid fuels, including high-viscosity and waste

oil, at a variable rate, with a greater BTU output capacity and reduced risk of furnace over- or under-firing, in a smaller size and with fewer elements than the prior art.

The basis of the invention requires a remote oil pump and compressed air supply, and comprises a two stage, on-demand oil preheating tank, a cumulative air pressure tank, air and oil solenoid valves, fuel igniter and a unique flame retention head.

There has thus been outlined rather broadly the more important features of this invention in order that the detailed description thereof that follows may be better understood, and in order that the present contribution to the art may be better appreciated.

There are, of course, additional features of the invention that will be described hereinafter and which will form the subject matter of the claims appended hereto. In this respect, before explaining at least one embodiment of the invention in detail, it is to be understood that the invention is not limited in its application to the details of construction and to the arrangement of the components as set forth in the following description or as illustrated in the drawings. The invention is capable of other embodiments and of being practiced and carried out in various ways. Also, it is to be understood that the phraseology and terminology employed herein are for the purpose of description and should not be regarded as limiting. As such, those skilled in the art will appreciate that the conception upon which this disclosure is based, may readily be utilized as a basis for designing other structures, methods, and systems for carrying out the several purposes of the present invention. It is important, therefore, that the claims be regarded as including such equivalent constructions insofar as they do not depart from the spirit and scope of the present invention.

Further, the purpose of the foregoing abstract is to enable the U.S. Patent and

Trademark Office, the public generally, and especially the scientists, engineers, and practitioners in the art who are not familiar with patent or legal terms and phraseology to determine quickly from a cursory inspection, the nature and essence of the technical disclosure of the application. The abstract is neither intended to define the invention of the application, which is measured by the claims, nor is it intended to be limiting as to the scope of the invention in any way.

Therefore, the objects of the present invention are:

(a) to provide a waste oil burner of safe, effective, efficient, and reliable operation;

(b) to provide a durable, low-maintenance waste oil burner;

(c) to provide a waste oil burner with an adjustable oil flow rate to accommodate a wide range of fuel compositions and viscosities;

(d) to provide a waste oil burner that does not leak fuel into the combustion chamber after the burner ceases operation without the use of oil solenoid valves;

(e) to provide a waste oil burner that does not require high-temperature fuel pre-heating;

(f) to provide a waste oil burner with a retention head that protects the combustion chamber by dissipating heat and controlling flame spread, limiting flame elongation, and promoting complete combustion;

(g) to provide a waste oil burner that is inexpensive to manufacture and is therefore affordable for purchase by small business owners;

(h) to provide a waste oil burner that is inexpensive to ship, install, operate, and maintain;

(i) to provide a waste oil burner that is simple to use and easy to adjust and maintain; and

(j) to provide a waste oil burner of relatively compact size and high BTU output.

(k) to provide a burner that is capable of expanding to increase BTU output

Further objects and advantages are to provide a burner with an oil dispersion system that is capable of forming atomized fuel into a pattern designed to better regulate the flame produced and to provide a burner with an adjustable BTU output that reduces or eliminates the need for manufacturers to offer several different furnace sizes to meet individual consumer heating requirements.

These factors, together with the other objects of the invention, and along with the various features of the aluminum preheater block, cumulative air tank and unique retention head which characterize the invention, are specified in the claims annexed to and forming calls part of this disclosure. For a better understanding of the invention, its advantages and the specific objects attained by its uses, reference should be made to the accompanying drawings and descriptive matter in which there are illustrated preferred embodiments of the invention.

The other two advantages of this unique air tank is, it slows the discharge of fuel so ignition occurs. In an acetylene torch, if one sets the flow rate too high, the torch cannot be ignited. A larger tip on the torch must be installed or the gas flow rate must be reduced. This is a problem with other waste oil burners on the market, they may advertise high BTU output; however when the air pressure is adjusted to a clean burning flame, their burners will not ignite. The Kagi burner will ignite the oil spray at high air pressures. The chemical law of combining, states a certain amount of oil needs a certain amount of oxygen for a complete burn. The aluminum preheater in the Kagi burner is set at 140 degrees F. when the burner is cycled off. When the burner is called to ignite, the oil heating element is energized. It comes on only when the burner is activated. This is

the reason the Kagi burner can go several years before the oil passages in the aluminum block needs wire brushing. This oil heater is enclosed in a chamber with less than 2 ounces of volume, and as the burner continues to operate, the oil exiting the nozzle becomes hotter and hotter. This is the reason the Kagi burner works the best in boilers, as oil impingement cannot be tolerated, as carbon and wet oil buildup can be a fire hazard.

The other benefit of the air tank (14) is when the burner cycles off, there is air pressure in the tank that blows out the residual oil left in the oil nozzle assembly, minimizing oil drippings from the nozzle. The effect of the gradual release of air from the cumulative air storage tank Fig. 1 (14) is similar to acetylene-oxygen torch where the pressure if too high, will prevent the torch from igniting. The gas flow must be reduced or a large tip must be install for the torch to be ignited.

CONCLUSIONS, RAMIFICATIONS AND SCOPE

Thus, the reader will see that the subject invention provides a simple, efficient, economical, and safe device designed for the combustion of liquid fuels, including high-viscosity and waste oil.

The present invention has been described herein as including various specific strictures, However, it will be apparent to those skilled in the art that various modifications or rearrangements of the described parts can be made without departing from the spirit and scope of the under-laying inventive concept. Thus, the present invention is not limited to the particular forms shown and described herein and reference is directed to the appended claims for a determination of the scope thereof.